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SOME ASPECTS OF MATURE PLANT RESISTANCE TO VIRUSES IN THE POTATO

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SOME ASPECTS OF MATURE PLANT RESISTANCE TO VIRUSES IN THE POTATO

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INTRODUCTION

It has been known for a long time that the older the potato plants are at the moment of inoculation with a virus, the fewer are the tubers that become infected. This phenomenon, studied in detail by BERCKS (1951, 1952) for potato virus X, is called mature plant resistance. In this paper some experiments will be described in which mature plant resistance was studied for the potato viruses X and leaf roll.

EXPERIMENTS WITH POTATO VIRUS X

For a number of years we studied the translocation of potato viruses in the potato from the inoculated leaf to the tubers. The following results were obtained from one of the field experiments with potato virus X in the variety Bintje. The tubers were planted on 25 April and the inoculation was performed on three leaflets of the youngest full-grown leaf of single-stemmed plants on the dates given in table 1.

TABLE 1. Tuber infection after inoculation of potato plants in different stages of growth.

Date of inoculation	Age when inoculated (weeks)	Height when inoculated (cm)	Percentage of tubers infected	
			Three weeks after inoculation	Five weeks after inoculation
5 June	6	10–12	100[1]	–
12 June	7	15–23	100	–
19 June	8	30–40	100	–
26 June	9	45–60	87	87
3 July	10	45–60	89	98
10 July	11	45–60	22	71
17 July	12	45–60	13	31
24 July	13	45–60	15	36

[1] The apical eyes of three tubers from 15 plants (total 45 per treatment) were tested.

The results clearly show that the older the plants are when inoculated, the smaller is the percentage of tubers infected. On the other hand real resistance in the older plants does not exist, for when the tubers were harvested five weeks after inoculation generally a higher percentage of infected tubers was found than three weeks after the inoculation. From this it can be concluded that the translocation of virus X from the leaf to the tubers continued from the third to the fifth week, even when the plants had been inoculated in an older stage.

Varietal differences in mature plant resistance to potato virus X

To find out if differences in mature plant resistance to virus X exist between different potato varieties, we compared the varieties Bintje, Eigenheimer, Voran and Bevelander;

Voran and Bevelander mature late, Bintje and Eigenheimer somewhat earlier. The experiment was performed in the green-house with single-stemmed potato plants, which had been planted on 6 June. On 13 July 20 plants of each variety were inoculated with potato virus X on the youngest full-grown leaf and on 27 July, two weeks after the first inoculation, another 20 plants of each variety were inoculated in the same way. Four plants of each variety were lifted respectively two, four, six, eight and ten days after inoculation. After testing the plants from the tubers for the presence of virus X with *Gomphrena globosa*, the results, given in table 2 were obtained.

It can be concluded that mature plant resistance was demonstrated in the varieties Bintje, Eigenheimer and Voran. The variety Bevelander, however, gave a rather high percentage of infected tubers also in the plants inoculated on 27 July. This late variety apparently stays in a young stage for a longer time than the other varieties. A higher percentage of infected tubers might be expected in Voran, because this also is a late variety, but relatively few infected tubers were found, even when young plants were inoculated.

TABLE 2. Tuber infection of different potato varieties inoculated with potato virus X in different stages of growth.

Variety	Days after inoculation	Inoculation on 13 July			Inoculation on 27 July		
		Plants with infected tubers (number/total)	Infected tubers (number/total)	%	Plants with infected tubers (number/total)	Infected tubers (number/total)	%
Bintje	2	0/4	0/20	0	0/4	0/22	0
	4	1/4	2/28	7	1/4	1/19	5
	6	2/4	2/27	7	1/4	1/27	4
	8	4/4	8/24	33	0/4	0/26	0
	10	4/4	8/14	57	1/5	1/36	3
Eigenheimer	2	0/4	0/18	0	0/4	0/19	0
	4	1/4	1/29	3	0/4	0/17	0
	6	2/4	4/19	21	1/4	1/15	7
	8	4/4	13/19	68	0/4	0/23	0
	10	4/4	17/23	74	2/5	2/28	7
Voran	2	0/3	0/9	0	0/4	0/12	0
	4	0/5	0/20	0	0/4	0/17	0
	6	0/3	0/16	0	0/4	0/8	0
	8	2/3	4/11	36	0/4	0/13	0
	10	4/4	8/19	42	1/5	1/16	6
Bevelander	2	0/4	0/13	0	0/4	0/16	0
	4	0/4	0/24	0	0/4	0/12	0
	6	1/4	2/21	10	0/4	0/23	0
	8	2/4	7/19	37	4/4	9/17	53
	10	4/4	16/23	70	4/4	15/20	75

EXPERIMENTS WITH POTATO LEAF ROLL VIRUS

Experiments on the movement of potato leaf roll virus from the inoculated leaves to the tubers have been done during the last five years. Single-stemmed potato plants were inoculated when young tubers were present by putting a number of infective

Myzus persicae on the leaves. The experiments were executed in aphid-free greenhouses.

Periodically some of the plants were lifted and afterwards the tubers were tested for the presence of leaf roll by growing them in pots. These experiments did not give any result because no infected tuber was found in any of the experiments.

To improve the method of inoculation we increased the number of aphids and used both potato and *Physalis floridana* as virus sources; moreover the way in which the aphids were put on the plants was changed, but the result was the same: no infected tuber could be found when plants were used that had already started tuber formation.

In 1953 an experiment was performed with rather young plants which had no tubers when inoculated. To obtain information about the movement of the virus through the stem of the plants, we cut off almost the whole stem of the plants at different times after inoculation. The plants formed new outgrowths which were allowed to grow for about six weeks to give the virus time to enter the tubers if it had been transported to the lower parts of the plants. The number of infected plants, when tested the tubers the next year, are given in table 3.

TABLE 3. Movement of potato leaf roll virus in young potato plants. Planting date: 1 August 1953. Inoculation date: 9 September 1953.

Stem removed after (days)	Inoculation in the top	Inoculation of one of the middle leaves
5	0/3[1]	–
7	1/3	0/3[1]
9	0/3	–
10	–	0/2
11	–	1/3
12	2/3	0/3
13	2/3	3/3
14	3/3	0/3
15	2/3	2/3
16	2/3	–
17	1/3	2/2
18	–	0/3
19	–	2/3

[1] Number of plants with infected tubers/Number of inoculated plants.

From table 3 it can be seen that a number of plants were infected, and that the translocation of the leaf roll virus downwards through the stem was observed for the first time seven days after inoculation.

In 1955 the following experiment was carried out: the stems of rather old single-stemmed potato plants, varieties Bintje and Eigenheimer, which had already formed tubers, were cut off almost completely (about 15 cm of the stems was left). Nine days later very small new shoots of less than 1 cm had been formed and aphids, carrying leaf roll virus were put on these new shoots. Four plants of each variety were harvested two, four, six, eight and ten days after inoculation. The number of plants infected when tested in 1956 are given in table 4.

TABLE 4. Infection of tubers with leaf roll virus after inoculating young sprouts developing on plants which had been cut off.

Harvested after (days)	Variety	
	Bintje	Eigenheimer
2	0/3[1]	0/4[1]
4	1/4	0/4
6	2/3	2/4
8	3/4	3/4
10	2/4	3/4

[1] Number of plants with infected tubers/number of inoculated plants

Table 4 shows that the transport of the virus from the young growing shoots to the tubers was very rapid.

In this experiment each tuber from the progeny was, if possible, cut into a number of pieces with one eye. From the results which are given in table 5 for the variety Bintje we see that the leaf roll virus does not penetrate to all parts of the tuber simultaneously, but after 10 days every part of the tuber was infected.

TABLE 5. Tuber infection with leaf roll virus at different times after inoculation (progeny of the variety Bintje, c.f. table 4).

Days after inoculation	Plant 1	Plant 2	Plant 3	Plant 4
2	−−	−	−−−−−−	
	−	−	−−−−−−	
4	−−−−	−−−	−−	−−+−
	−−	−−	−−	−+−−
	−	−		−−
		−		+
				−
6	+	−−−−−	+++	
	−	−−	+++	
	+	−−	−−	
	+	−−	++	
		−	−−	
			−	
			−	
			−	
8	+++++	+++	−−−	−−−
	+−	+	+	−−−
	−	−	+	−−
		−		−
10	−−−	+++++++++	+++	−−−
	−−−	+++++++	+++	−−−
	−−−		+	−−
	−−		+	−−
				−−
				−

Horizontal: number of eyes per tuber; vertical: number of tubers per plant; + : tuber or eye infected; −: tuber or eye healthy.

The results of the experiments suggest that mature plant resistance to leaf roll virus exists as well as to virus X. It can be concluded that it is much easier to infect young growing parts of a potato plant than the older parts, at least under green-house conditions. No doubt the same holds for plants in the field and the phenomenon is of interest in relation to the epidemiology of leaf roll. The aphids which appear early in the season may be very important as vectors. The results further indicate that aphids which feed on plants that have stopped leaf and stem growth may be of little importance. However, it must be kept in mind that in the field there is often a new outgrowth of lateral shoots and aphids may easily infect such shoots. Such infection may be particularly important after foliage has been incompletely destroyed by spraying chemicals or mechanically.

The cause of the mature plant resistance to viruses in the potato plant still has not been elucidated. BERCKS (1951) suggested that the breakdown of virus in older plants might be of importance. Our experiments showed, at least in the case of potato virus X that it is not a question of resistance to infection. In most cases we were able to diagnose the virus in the inoculated leaves even when old plants were used. Whether it is caused by a lower degree of virus multiplication in the inoculated leaves or whether it must be attributed to the fact that the vascular system becomes less penetrable for the virus as the plants grow older, is not known at present.

SUMMARY

Mature plant resistance in potatoes to virus X was demonstrated in the varieties Bintje, Eigenheimer and Voran. Experiments over a number of years with potato leaf roll virus showed that mature plant resistance to the leaf roll virus exists as well. This fact may be of importance for growing seed potatoes. At present the cause of the mature plant resistance is unknown.

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DISCUSSION

ROZENDAAL: Were the eyes at the heel end or those at the top end of the tubers infected with leaf roll virus? With virus Y for instance we have the experience that the top end eyes are more and earlier infected than the eyes at the heel end.

BEEMSTER: I have not found differences in infection with leaf roll virus between top end and heel end eyes, but the experiments were too small to give a definite answer.

KÖHLER: If the leaves ripen normally it is imaginable that when the plant is being exhausted the virus is also transported to the tubers. Has Mr BEEMSTER results of experiments which would support this view?

BEEMSTER: I have also carried out experiments in which the haulms matured and died before I harvested the tubers. However, I always found tubers which were only partially infected which may indicate that in these plants the mechanism of virus translocation is hampered in one way or another.

KÖHLER: In experiments with potato virus X in tobacco I found that in older plants movement of virus towards the tip of the plants is much slower than in young plants. It even may occur that plants are so old that virus cannot reach the top anymore. I assume that virus inactivation in such cases

occurs in the vascular system. It may be that in potato plants a similar event takes place but then when virus is moving from the tip of the plant to the tubers.

BROADBENT: DONCASTER & GREGORY (Agr. Res. Counc. Rep. 7, 1948) found late spread of leaf roll when haulm growth was excessive in wet seasons or on certain types of soils, and attributed this to ease of aphid movement from plant to plant. Mr BEEMSTER's results suggest that this phenomenon may be due partly to the amount of susceptible young growth under such conditions. Perhaps Prof. BALD could tell us if there is much young growth in Australian potatoes, in which he told us the other day that leaf roll spreads rapidly because aphids move frequently.

BALD: Late growth of long stems prevented localisation of virus around primary sources of infection. Therefore luxurious growth of stems probably aids movement of aphids. On the other hand it does seem likely that renewed growth encourages infection of tubers. I think both factors are involved in infection of larger numbers of tubers.

BROADBENT: Has Mr BEEMSTER tried to infect old and young shoots on groups of plants of the same age?

BEEMSTER: No, I have not yet done that.

LISTER: Am I correct in assuming that testing for virus X in tubers in the mature plant resistance experiments you described, was done on the plants grown from the tubers? If so, do you think it likely that some tubers or eyes containing virus might produce plants in which virus X could not be detected?

BEEMSTER: Yes, in the mature plant resistance experiments with virus X the progeny of the test plants were tested for the presence of that virus. Tubers of primarily infected plants often have eyes which give rise to either healthy or diseased plants. It does not seem likely that virus X escapes detection in plants grown from tubers or eyes containing the virus. Regarding tubers of secondarily infected plants, they always only produce virus X-infected plants.

SPRAU: It was of great interest to me that my investigations with leaf roll virus using the colour test gave similar results as those described by Mr BEEMSTER. This applies as well to the slow movement of leaf roll virus in inoculated older plants, as to the fact that the tubers may remain partially virus-free. However, I could not find the quick movement of leaf roll virus in young shoots from the leaf where it was introduced to the tubers. This may be due to the fact that a colour reaction is only obtained some time after the virus moved into the phloem tissue.

BEEMSTER: The distribution of the virus in the tubers indicates that the concentration of the virus is very small and it may take a considerable time before a positive colour reaction is obtained.

DRUK: H. VEENMAN EN ZONEN, WAGENINGEN

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